Contribution to the analysis of certain technological aspects of soft wheat seeds treated with purified wastewater

Nadia CHIAHI[1*] and Messaouda REZAGUI[2]
1.Laboratory for Terrestrial and Aquatic Ecosystems, Mohamed-Cherif Messaadia University of Souk Ahras, Algeria.
2.Toxicology Laboratory, Faculty of Medicine, Department of Pharmacy, UBM Annaba, Algeria.

Abstract

Our objective in this study was first to evaluate the technological quality of soft wheat treated with purified wastewater. In the second phase, we aimed to study and compare various physiological and biochemical parameters of two soft wheat varieties (*Triticum aestivum* L.), El-Hiddab (HD1220) and Béni Sélimane (ARZ), irrigated with either rainwater or purified wastewater. According to our findings, the use of purified wastewater is beneficial for technological parameters such as moisture, ash, gluten, and chlorophyll content in soft wheat. The analytical results of our experiments largely comply with national standards.

Keywords: soft wheat, irrigation, purified wastewater, technological parameters, viability and vigor, accelerated aging

CHIAHI, N. and M. REZAGUI, 2024. Contribution to the analysis of certain technological aspects of soft wheat seeds treated with purified wastewater. *Iranian Journal of Plant Physiology 14* (3), 5155-5167.

Introduction

Cereal cultivation is a significant factor in Algerian agriculture (Noura et al., 2021). Among these cereals, common wheat is widely used in the diet of Algerian populations. However, its output remains extremely low and does not exceed 1.02 MT (Fellahi, 2017).

Many countries today, and possibly in the future, face the most difficult issue, which is the lack of water. According to the World Bank, drinking water shortages will affect over five countries and over 3 billion people by 2025. The WHO estimates indicate that around 20% of the world's population is unable to obtain quality drinking water (Bouziani, 2000).

By using treated wastewater in agriculture, the consumption of traditional water resources that are no longer suitable for intensive agriculture can be reduced, and the water deficit can be mitigated (Eddabra et al., 2011).

In arid and semi-arid climates, treated wastewater serves as an important source of water and nutrients for many farmers. It is sometimes the only source of water available for agriculture. Proper management of wastewater use can help recycle nutrients and water, reduce land amendment costs, or simply make these resources accessible to farmers (Sciarini et al., 2017).

In addition, the reuse of treated wastewater in agriculture can also bring additional benefits due

---

** Corresponding Author*
E-mail Address n.chiahi@univ-soukahras.dz
Received: January, 2024
Accepted: March, 2024

to the nature of wastewater, which is rich in fertilizing elements as well as trace elements that are beneficial for crops by increasing their yields (Jaramillo and Restrepo, 2017), especially for the cultivation of soft wheat, which is one of the main sectors of agricultural production in Algeria and is widely used in food (Rahal-Bouziane et al., 2015).

This work focuses on examining some technological parameters of soft wheat seeds that have been treated with purified wastewater.

Materials and Methods

This study is aimed at performing physicochemical and technological analyses on soft wheat treated with purified wastewater. The University of Mohamed Cherif Messadia's plant biology laboratory and the Grands Moulins Belghith's laboratory of analysis and quality control were both involved in conducting two experiments. Souk-Ahras (Algeria).

Plant material.

This work involves the irrigation of two soft wheats (*Triticum aestivum* L.) varieties, El-Hiddab (HD1220) and Beni Sélimane (ARZ) from the 2021 harvest of Sedrata (Souk ahras) pilot farmTidjani.

Conduct of the Test

1st Attempt - Germination in Petri Dishes

In our Plant Biology Laboratory at Mohamed Chérif Messaadia University, we selected a total of 60 seeds for this experiment. Of these, 30 seeds were irrigated with rainwater, and another 30 seeds were irrigated with a solution made from mashed wastewater. The seeds were sterilized using 2.5% sodium hypochlorite (bleach) for 5 minutes and then rinsed six times with distilled water to remove any residual bleach. The seeds were selected based on their morphology, size, color, and overall appearance. After sterilization, 10 seeds were placed in each Petri dish, resulting in a total of 12 Petri dishes (Fig. I)

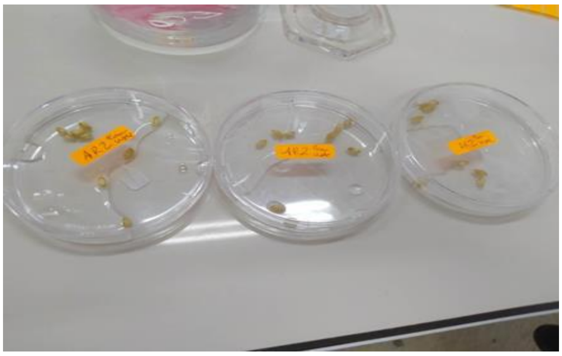
Fig. I. Germination in Petri Dishes

The Petri dishes were kept at room temperature in the laboratory for 7 days. Each variety of seeds was irrigated with 10 mL of tap water to facilitate germination.

2nd Attempt: Accelerated Aging

This attempt is used to predict the viability of wheat grains at an early stage, which is highly beneficial for post-harvest grain management organizations. A sample of wheat grains from each variety is sterilized with 2.5% sodium hypochlorite (bleach) for 5 minutes and then rinsed six times with distilled water. The sterilized grains are then placed in an oven at 45°C and left for 48 to 72 hours to undergo accelerated aging. After this period, the grains are removed and allowed to germinate for 7 days at room temperature in the laboratory, with 10 mL of tap water provided to each variety to facilitate germination.

3rd Attempt: Cultivation in Pots

This experiment was conducted to facilitate the transport of fresh material from the test site to the university laboratory. We prepared 16 rectangular pots measuring 30 cm in length, 11.5 cm in width, and 14.5 cm in height, with four replicates for each variety (Fig II). The seeds were disinfected with 5% bleach for 5 minutes and then rinsed thoroughly with distilled water. They were then sown at a depth of 3 cm in an orderly fashion, with 2 rows per pot and 2 cm spacing between the seeds. The pots were placed randomly in the laboratory at room temperature, with 60 seeds sown in each pot.The sowing of wheat seeds was carried out on January 11, 2023.

Composition of the Soil Substrate

Fig. II. Pots of treated varieties

The substrate used consisted of a mixture of soil and sand in a 2:1 volume ratio. After drilling holes at the bottom of the pots, a layer of gravel was added to the base, comprising 10% of the total volume. Before use, the soil was sieved to remove plant debris.

Parameters Studied

Texture of Soil

Soil texture was determined using Soltner's (2007) method, which involves comparing the percentage of soil moisture (H%) and analyzing the corresponding soil texture.

pH Determination

Soil pH was classified according to Joshi method (Joshi, 2021). The acidity of the soil exchange is measured in pH-KCl. *pH-KCl* measures the concentration of hydrogen ions (H+) in the soil after the addition of KCl. This is determined using the method described by Baize and coworkers methods (Baize and Jabiol, 2011), which involves removing the H+ ions fixed on the soil's humic complex. *Electrical Conductivity (EC)* Electrical conductivity is crucial for determining soil salinity. A conductivity meter is used to measure the electrical conductivity of a soil extract (soil/water ratio = 1:5), and the results are compared on a salinity scale.

Salinity Determination

Soil salinity was assessed following the method outlined by the U.S. Salinity Laboratory (Laboratory, 1954). The procedure involved preparing a soil-water extract and measuring its electrical conductivity (EC), which is an indicator of the soil's salinity level. Soil samples were collected from the experimental pots at a specified depth. The samples were air-dried at room temperature and passed through a 2 mm sieve to remove any coarse particles and debris. To determine salinity, a 1:5 soil-to-water extract was prepared by mixing 1-part soil with 5 parts distilled water. The mixture was stirred thoroughly and allowed to settle for 30 minutes. The supernatant was then filtered to obtain a clear extract.

Physiological and Biochemical Parameters

Chlorophyll Pigment Content

Chlorophyll content was measured using the traditional methods of Arnon (Arnon, 1949) and Hiscox & Israelstam (Hiscox and Israelstam, 1979). Chlorophyll was extracted from leaf tissue by macerating the vegetative tissue with acetone. Using an 80% acetone control solution, the apparatus was calibrated, and the optical density was measured at two wavelengths: λ1 = 645 nm and λ2 = 663 nm. Chlorophyll levels were estimated in µg/g fresh weight (FW) using the following formulas (Arnon, 1949):

$$\text{Chlorophyll a} = (12.25 \times OD_{663.2}\,\text{nm} - 2.79 \times OD_{646.8}\,\text{nm})$$

$$\text{Chlorophyll b} = (21.21 \times OD_{646.8}\,\text{nm} - 5.1 \times OD_{663.2}\,\text{nm})$$

$$\text{Total Chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

$$\text{Carotenoid} = [(1000 \times OD_{470}\,\text{nm} - 1.8 \times \text{Chlorophyll a} - 85.02 \times \text{Chlorophyll b})/198]$$

OD: optical density (value given by the spectrophotometer)

Protein Quantification

Total protein content was quantified using the Bradford method (Bradford, 1976), which involves enzymatic extraction of proteins followed by colorimetric analysis. Fresh plant tissue samples were homogenized in an appropriate buffer (e.g., phosphate buffer or Tris-HCl) containing a protease inhibitor to prevent protein degradation. The homogenate was then centrifuged at 12,000 x g for 15 minutes at 4°C to separate the soluble protein fraction from the cell debris. The protein concentration in the supernatant was determined using the Bradford reagent, which contains Coomassie Brilliant Blue G-250 dye. When the dye binds to the protein, it undergoes a shift in absorption maximum from 465 nm to 595 nm. The absorbance was measured at 595 nm using a spectrophotometer.

Total Protein Assay

The total protein content was determined using a calibration curve generated by the Bradford protein assay. The relationship between absorbance and protein concentration was established using a linear regression equation.

Calibration Curve Preparation: A series of bovine serum albumin (BSA) standards with known concentrations (e.g., 0, 10, 20, 40, 60, 80, 100 µg/mL) were prepared in the same buffer used for protein extraction. The Bradford reagent was added to each standard, and the absorbance was measured at 595 nm using a spectrophotometer.

The absorbance values obtained for the BSA standards were plotted against their respective protein concentrations to generate a standard curve. The linear regression equation obtained from the curve is:

$$y=0.0115x+0.0187$$

where y is the absorbance at 595 nm, and x is the protein concentration in µg/mL. The coefficient of determination (R^2) for the calibration curve is 0.994, indicating a strong linear relationship between absorbance and protein concentration (Fig III).

Protein Quantification: The absorbance of the protein extracts from the plant samples was measured at 595 nm, and the corresponding protein concentration was calculated using the regression equation. The results were expressed as µg of protein per mL of extract.

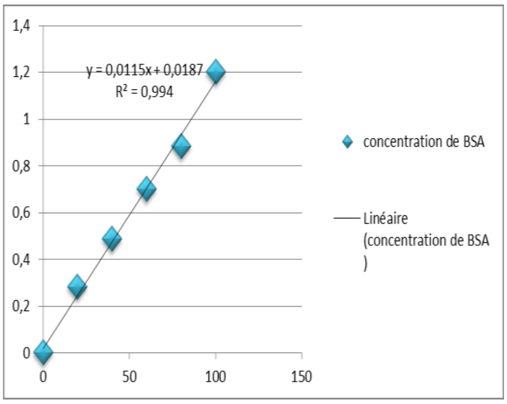

Fig. III. Calibration curve for protein quantification using the Bradford assay

Technological Parameters

This study was conducted at the mill laboratory level of « LES GRANDS MOULINS BELGHITH » in M'daourouch, Souk Ahras, Algeria, one of the largest milling complexes in Algeria.

Biological Material Used

Purified rainwater was used to irrigate two varieties of common wheat, El-Hiddab (HD1220) and Béni Sélimane (ARZ), both of which are known as *Triticum aestivum* L.

Moisture Determination

Moisture content was measured using the standard method for flour to determine whether the product is wet or dried. The moisture content of the product, expressed as a percentage by mass, is calculated as follows:

$$H\%=(m_1-m_0)\ (m_1-m2)\times 100$$

where:
H% is the humidity percentage,
m_0 is the mass in grams of the empty nacelle (tare),
m_1 is the mass in grams of the empty basket and the test sample before dehydration,

m_2 is the mass in grams of the empty nacelle and test sample after dehydration.

Determining the Ash Content

Ash content is determined by heating a test sample to 900 °C under specified conditions, expressed as a percentage by mass. The process is typically performed using a Nabertherm LHT 02 LB muffle furnace. Introduce the test sample into an oxidizing atmosphere at a temperature of 900 °C ± 25 °C until the organic matter burns completely, then weigh the resulting residue (Fig IV).

Fig. IV. Determination of Ash Content in Wheat Samples Using a Nabertherm LHT 02 LB Muffle Furnace.

Impurity Rate (Aggregation)

To accept a commodity, especially in milling, involves a visual analysis step that verifies the quality of wheat according to the contract established between the buyer and the seller.

Extraction Rate

The extraction rate represents the percentage of flour extracted from grinding 100 kg of clean wheat. Both the type of wheat used and the mill's settings influence this rate (Ahmed et al., 2020).

Determination of the Water Content of Flours (Finished Products)

To measure the water content in flours, the Algerian standard NA 1333/1990 (which aligns with ISO 712:2009) outlines a standard procedure. This method involves:

Sample Preparation: A precise amount of flour, typically 5 grams, is weighed.

Heating: The flour sample is placed in an oven heated to 130°C. This temperature is chosen to effectively evaporate the moisture content without altering the chemical composition of the flour.

Duration: The sample is heated for one and a half hours. This duration ensures that all moisture is completely evaporated.

Measurement: After heating, the sample is weighed again. The difference in weight before and after heating indicates the amount of water that was present in the flour. The water content is expressed as a percentage of the total mass of the flour sample. This method is crucial for ensuring the quality and consistency of flour in various applications (Fig V).

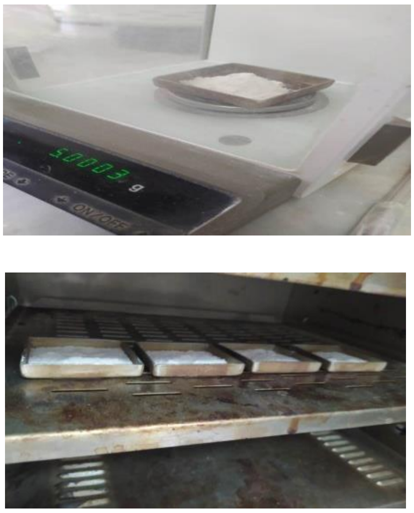

Fig. V. Technique for determining the water content of flours

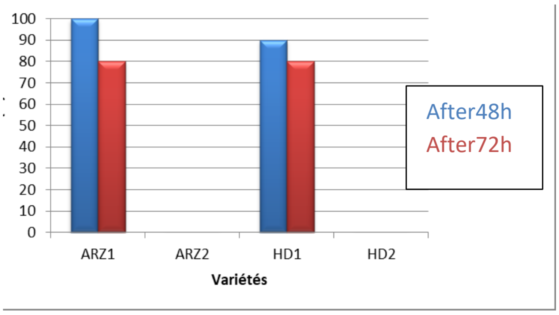

Fig. VI. Germination rate after accelerated aging tests

Results

The physical analyses of the non-irrigated soil were conducted to assess its suitability for agricultural use. The key parameters measured include soil texture, pH, pH (KCl), salinity, and electrical conductivity, as summarized in Table 1.
Soil Texture: The soil texture was identified as sandy loam, which is typically well-draining and supportive of root development, making it suitable for a wide range of crops. Soil pH: The pH value of the soil in water (pH H_2O) was measured at 7.3, indicating a neutral pH level. The pH in a potassium chloride solution (pH KCl) was slightly higher at 7.38. Both pH values suggest a neutral to slightly alkaline condition. Comparison of pH (H_2O) and pH (KCl): The difference between pH (H_2O) and pH (KCl) was minimal (0.08 units). This small variation suggests that the soil has a stable pH and low buffering capacity. Salinity and Electrical Conductivity (EC): The soil salinity level was recorded at 1.13, and the electrical conductivity (EC) was 0.58 mS/cm. These values indicate that the soil is non-saline, as soils with EC below 0.6 mS/m are generally considered non-saline.

Table 1.
Soil Physical Parameters

Parameter	Value
Texture	Sandy loam
pH (H_2O)	7.3
pH (KCl)	7.38
Salinity	1.13
Electrical Conductivity (mS/cm)	0.58

The physiological and biochemical parameters of different plant varieties (ARZ1, HD1, ARZ2, and HD2) were analyzed to understand their response to different treatments, including irrigation with treated wastewater and accelerated aging (VA) tests. The mean values of the studied parameters are presented in Table 2. The germination rate varied significantly between the varieties and treatments used. As shown in Table 2, the ARZ1 variety, irrigated with clean wastewater, exhibited the highest germination rate at 93.33%, followed by HD1 at 83.33%. In contrast, the ARZ2 and HD2 varieties did not germinate (0% germination rate). The data indicate that treated wastewater had a beneficial effect on the germination rate of ARZ1 and HD1, while ARZ2 and HD2 showed no germination. The germination rates after accelerated aging tests (VA) are presented in Fig.VI. After 48 hours, the ARZ1 and HD1 varieties exposed to treated wastewater maintained high germination rates, showing that nearly all seeds remained viable.

After 72 hours, there was a slight decrease in germination rates for both ARZ1 and HD1 varieties, although they remained high, indicating good seed viability even under stress conditions. The ARZ2 and HD2 varieties, however, showed no germination at either 48 or 72 hours, demonstrating low resilience under accelerated aging conditions.

The root length analysis Table 2 showed that ARZ1 had the longest roots at 21.66 cm, followed by HD1 at 12.83 cm. The other varieties, ARZ2 and HD2, had no root growth (0 cm). Longer root lengths suggest that the varieties with longer roots, such as ARZ1, were in more nutrient-rich environments and adapted their root systems accordingly.

Root lengths after accelerated aging treatment were analyzed and shown in Fig. VII. After 48 hours, ARZ1 seeds had the longest roots (15.66 cm), while ARZ1 and HD1 seeds aged for 72 hours showed shorter root lengths (13 cm and 11 cm, respectively). This indicates that root length decreased with longer aging periods, showing the effects of stress conditions on root development.
The chlorophyll content of the ARZ2 and HD2 varieties treated with water reached 25 µg/g, according to Table 2. However, the concentration

Table 2.
Physiological and biochemical mean parameters analyzed (Mean ± SE)

Studied	Purified waste water		rainwater	
	ARZ1 (Mean ± SE)	HD1 (Mean ± SE)	ARZ2 (Mean ± SE)	HD2 (Mean ± SE)
Germination rate (%)	93.33 ± 2.10 a	83.33 ± 1.85 b	0 ± 0 c	0 ± 0 c
Root length (cm)	21.66 ± 0.95 a	12.83 ± 0.75 b	0 ± 0 c	0 ± 0 c
Chlorophyll a (µg/g)	15.89 ± 1.12 b	10.46 ± 0.98 c	25.80 ± 1.34 a	10.08 ± 0.89 c
Chlorophyll b (µg/g)	20.10 ± 1.05 b	10.49 ± 0.92 c	28.88 ± 1.45 a	32.87 ± 1.50 a
Chlorophyll (a + b) (µg/g)	35.98 ± 1.56 b	20.95 ± 1.20 c	54.66 ± 2.08 a	42.93 ± 1.75 a
Total protein (µg/g)	71.15 ± 3.00 a	15.13 ± 0.88 b	15.64 ± 0.95 b	7.88 ± 0.50 c

*Different letters indicate significant differences according to the Duncan test (P ≤ 0.05)

Table 3.
Comparative Analysis of Quality Characteristics in Different Grain Samples.

Metric	ARZ1	HD1	ARZ2	HD2
Humidity (%)	9.57 ± 0.15 a	9.21 ± 0.10 a	10.71 ± 0.12 b	12.63 ± 0.14 b
Weight (thousand grams) (g)	41.86 ± 0.25 a	33.15 ± 0.20 b	28.17 ± 0.30 c	34.71 ± 0.15 b
Specific Weight	79.62 ± 0.18 a	81.76 ± 0.22 a	83.30 ± 0.15 b	76.16 ± 0.20 b
Whole Grains (%)	85.89 ± 0.20 a	91.72 ± 0.10 a	85.61 ± 0.15 a	88.59 ± 0.12 a
Broken Grains (%)	5.84 ± 0.30 a	1.77 ± 0.20 b	1.93 ± 0.25 b	5.72 ± 0.15 a
Scalded Grains (%)	3.84 ± 0.15 a	1.93 ± 0.10 b	5.55 ± 0.12 a	1.75 ± 0.08 b
Small Grains (%)	2.28 ± 0.05 a	4.58 ± 0.08 a	6.91 ± 0.10 b	-
Moldy Grains (%)	-	-	-	-
Various Plants (%)	0.36 ± 0.02 a	-	-	-
Presence of Other Cereals (%)	0.04 ± 0.01 a	-	-	0.96 ± 0.05 b
S - Speckled Grains (%)	1.70 ± 0.03 a	-	-	2.98 ± 0.04 b
Metric	ARZ1	HD1	ARZ2	HD2
Humidity (%)	9.57 ± 0.15 a	9.21 ± 0.10 a	10.71 ± 0.12 b	12.63 ± 0.14 b
Weight (thousand grams) (g)	41.86 ± 0.25 a	33.15 ± 0.20 b	28.17 ± 0.30 c	34.71 ± 0.15 b

*Different letters indicate significant differences according to the Duncan test (P ≤ 0.05)

Table 4.
Ash Content Percentage and Standard Error of Different Varieties.

Variety	Ash Content %
ARZ1	0.97 ± 0.05 a
ARZ2	0.55 ± 0.02 b
HD1	0.70 ± 0.04 ab
HD2	0.83 ± 0.03 ab

*Different letters indicate significant differences according to the Duncan test (P ≤ 0.05)

Table 5
Gluten Content Analysis of flours in different varieties

Variety	Wet Gluten(%)	Dry Gluten (%)
ARZ1	27.18±0.05a	10.42±0.02a
ARZ2	30.86 ±0.05b	10.90±0.03a
HD1	28.72±0.05ab	10.60±0.02a
HD2	29.09±0.05ab	9.60±0.03b

*Different letters indicate significant differences according to the Duncan test (P ≤ 0.05)

of chlorophyll decreased in these same varieties when treated with wastewater. This pattern was also observed for chlorophyll b. While ARZ2 and HD2 showed the highest chlorophyll b values, the

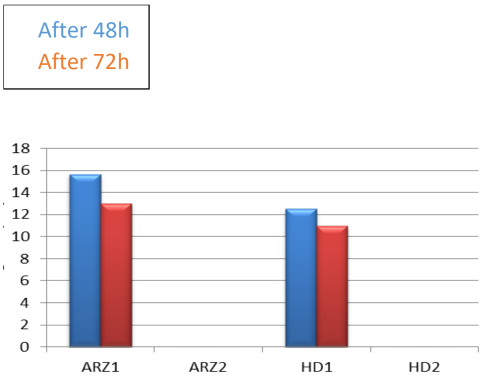

Fig. VII. Root length after the accelerated aging test.

ARZ1 and HD1 varieties irrigated with treated wastewater exhibited a decline in the formation of chlorophyll b pigments.

The protein content of four wheat varieties (ARZ1, ARZ2, HD1, and HD2) is presented in the graph. The highest protein content is observed in ARZ1, with a value of 71.15 µg/g MF. In contrast, the other varieties have significantly lower protein levels, with ARZ2, HD1, and HD2 having 15.64 µg/g MF, 15.13 µg/g MF, and 7.88 µg/g MF, respectively (Table 2).

Table 3 shows that the moisture values of the raw material in the four varieties range from a minimum of 9.21% for HD1 to a maximum of 12.63% for HD2. These results indicate that none of the varieties exceed the upper limit tolerated by the Algerian standard, which recommends a maximum humidity of 12%.

This study examines the quality characteristics of four different samples (ARZ1, HD1, ARZ2, and HD2) in terms of various metrics, including humidity, weight, specific weight, and grain composition. The data provides insights into the physical and qualitative differences among the samples, which can inform agricultural practices and product selection (Table3).

The analysis indicates a variation in the ash content of the wheat varieties analyzed, with ARZ1 showing the highest ash content at 0.97% and ARZ2 the lowest at 0.55%. These results comply with the Algerian standard, which permits a maximum ash content of 1% (Table 4).

The extraction rate for the samples was found to be 71.5%, which is lower than the theoretical average of 75% (Fig. IX).

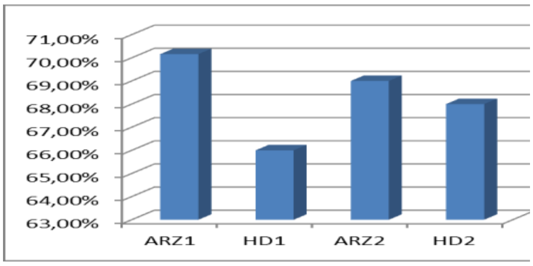

Fig. IX. Extraction rate of different wheat varieties.

The water content of the flours analyzed in this study ranged from 9-12% (Fig X), which is lower than the values reported by Granvoinnet and Pratx (1994), who found water contents of 13-16%.

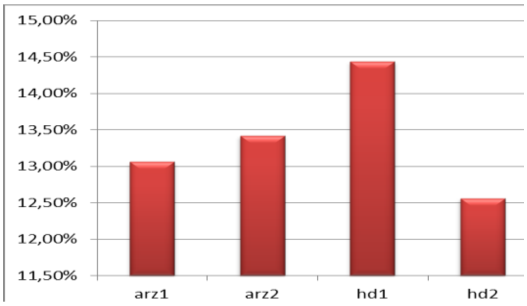

Fig. X. Water contents of flours in different varieties

The gluten content analysis showed that ARZ2 had the highest wet gluten at 30.86 ± 0.05% (b), while HD2 had the lowest dry gluten at 9.60 ± 0.03% (b). ARZ1 and HD1 had similar wet gluten levels, around 27-29% (a, ab), and their dry gluten content was statistically similar to ARZ2. The variations suggest that ARZ2 is better suited for applications requiring higher moisture retention, while HD2 may be less effective in maintaining structural integrity in baked goods (Table 5). Variations suggest that ARZ2 is better suited for applications requiring higher moisture retention, while HD2 may be less effective in maintaining structural integrity in baked goods (Table 5).

Discussion

The neutral pH of 7.3 is classified as ideal for most crops (Joshi, 2021). Since the pH (KCl) is only slightly higher than the pH (H_2O) by 0.08 units, it remains within the acceptable range suggested by Angelova and coworkers (Angelova et al., 2021). A difference exceeding 0.5 to 1 unit could lead to mineral nutrition problems for plants, but in this case, the stability of pH suggests no risk of nutrient deficiencies or toxicities.

The measured EC value of 0.58 mS/cm is below the 0.6 mS/m threshold, classifying the soil as non-saline according to the Minhas (Minhas, 2021). Non-saline soils like this one do not pose a risk of salt stress, which is favorable for crop growth.

Given the neutral pH and non-saline conditions, the soil does not pose any significant risks to crops, as noted by some researchers (Achag et al., 2021; Minhas, 2021). The sandy loam texture also suggests good water drainage and aeration, which are beneficial for root health and plant growth.

The sustained germination rates in ARZ1 and HD1 after 72 hours suggest that these varieties possess robust physiological mechanisms that allow them to maintain seed vigor even under adverse conditions. The slight reduction in germination rates may be due to the inevitable effects of aging stress, such as the accumulation of reactive oxygen species (ROS) and other damaging factors that can impair seed metabolism (Li et al., 2022). However, their ability to continue germinating at high rates indicates that they have efficient antioxidant defense systems and repair mechanisms, which protect the seeds from excessive oxidative damage (Adetunji et al., 2021). On the other hand, the complete lack of germination in ARZ2 and HD2 at both time points highlights the vulnerability of these varieties to aging stress. The absence of germination indicates a severe loss of seed vigor, likely caused by oxidative damage and degradation of cellular structures during the VA test (Izzo et al., 2021). The inability of these seeds to germinate even after 48 or 72 hours suggests that ARZ2 and HD2 varieties may lack the necessary physiological traits to withstand aging-induced stress, making them less suitable for use in stressful environments.

The positive effects of treated wastewater on the germination rates of ARZ1 and HD1 can be attributed to the nutrient-rich composition of the wastewater, which may enhance seed vigor and promote early seedling establishment. Previous studies have demonstrated that treated wastewater can improve germination and growth due to its nutrient content, which can mimic the role of fertilizers (Zaouri et al., 2021). This is particularly evident in ARZ1, which maintained the highest germination rate, possibly due to its genetic capacity to utilize available nutrients more efficiently than the other varieties. In contrast, the lack of germination in ARZ2 and HD2 suggests that these varieties may be more vulnerable to stress conditions, including the composition of treated wastewater. These varieties may possess less efficient mechanisms for coping with stress-induced by wastewater components, leading to their failure to germinate(Das and Biswas, 2022).

Accelerated aging is commonly used to assess seed vigor, as it exposes seeds to controlled stress conditions that mimic the effects of aging and environmental stress (Fenollosa et al., 2020). The ability of ARZ1 and HD1 to retain high germination rates after VA tests demonstrates their superior seed quality and resilience compared to ARZ2 and HD2.

Longer root lengths in varieties such as ARZ1 may indicate their ability to explore and exploit more nutrient-rich environments. Root growth is often closely linked to the availability of essential nutrients such as nitrogen, phosphorus, and potassium in the soil, as roots elongate to access these resources(Du et al., 2021). According to (Du et al., 2021), plants in nutrient-rich environments tend to develop more extensive root systems to optimize nutrient uptake, which may explain the superior root length observed in ARZ1. Additionally, ARZ1’s longer roots may also reflect its genetic capacity to adapt to varying environmental conditions by prioritizing root development. In contrast, the complete lack of root growth in ARZ2 and HD2 suggests that these varieties were either unable to adapt to the environmental conditions or that some external factors inhibited their root development. Environmental stresses such as nutrient deficiency, drought, or salinity are known to severely restrict root growth in susceptible varieties (Kul et al., 2020). The absence of root growth in these varieties might indicate their sensitivity to suboptimal conditions, leading to their inability to initiate or sustain root development. Additionally, the difference in root lengths between ARZ1 and HD1 seeds suggests genetic variation in the seeds’ responses to aging-induced stress. Genotypes with stronger antioxidative systems or enhanced vigor may have a higher tolerance to oxidative stress, allowing for better root development under aging conditions (Adetunji et al., 2021). The fact that ARZ1 seeds had longer roots after 48 hours and retained a relatively higher root length than HD1 after 72 hours indicates that ARZ1 might possess mechanisms that allow for greater resilience against aging.

The results indicate that chlorophyll content, both for chlorophyll a and b, was significantly influenced by the type of irrigation. Water-treated ARZ2 and HD2 varieties had the highest chlorophyll concentrations, suggesting that these varieties were better able to maintain optimal photosynthetic pigment levels in favorable conditions. Chlorophyll a, being the primary pigment involved in light absorption and energy transfer during photosynthesis, is crucial for the proper functioning of photosystem II (Shevela et al., 2021). The observed decrease in chlorophyll a levels in ARZ2 and HD2 under treated wastewater conditions suggests that the wastewater components may negatively impact the chlorophyll synthesis or stability in these varieties.

Chlorophyll b, which plays a complementary role by absorbing light at different wavelengths than chlorophyll a, helps to maximize the utilization of available sunlight (Simkin et al., 2022). The higher levels of chlorophyll b in ARZ2 and HD2 varieties suggest a greater capacity for light harvesting under optimal conditions. However, the decrease in chlorophyll b observed in ARZ1 and HD1 varieties irrigated with treated wastewater may reflect a stress response or a reduced capacity for chlorophyll production under suboptimal conditions. Treated wastewater often contains components such as heavy metals or salts, which can inhibit chlorophyll biosynthesis or accelerate chlorophyll degradation, reducing the efficiency of photosynthesis (Khalilzadeh et al., 2020). This may explain why ARZ1 and HD1, when irrigated with treated wastewater, showed reduced chlorophyll b formation compared to ARZ2 and HD2 varieties. The differences in pigment concentrations among the varieties point to varying levels of tolerance to wastewater irrigation, with some varieties being more resilient to the potential stress factors present in the wastewater.

The results indicate that treated wastewater has a positive impact on the protein content of soft wheat, particularly in the ARZ1 variety, which exhibited the highest protein levels among the four varieties. This finding suggests that the nutrients present in treated wastewater, such as nitrogen, phosphorus, and trace minerals, may play a significant role in enhancing protein synthesis and accumulation in wheat. According to some researches (Dradrach et al., 2022), wastewater can act as a source of essential nutrients that promote plant growth and improve the nutritional content of crops, including protein levels. The elevated protein content in ARZ1 compared to the other varieties may also be attributed to genetic differences in nutrient absorption and utilization efficiency. Varieties like ARZ1 may possess a higher capacity to absorb and assimilate nutrients from wastewater, leading to improved protein biosynthesis. Protein content is closely linked to nitrogen availability in the soil, and treated wastewater is often rich in nitrogen compounds, which are essential for amino acid and protein synthesis (Zheng et al., 2021). This could explain the increased protein levels observed in the ARZ1 variety.

The water content of tender wheat varieties is of critical importance both economically and for food preservation (Awulachew, 2020). Varieties ARZ1 and HD1, with moisture values below 12%, can be classified among dry wheats. According to Kibar research (Kibar et al., 2021), Algerian wheats generally have a lower moisture content compared to imported varieties. This characteristic suggests that during the conditioning stage, only small amounts of water would need to be added due to their limited moisture storage capacity.

The high humidity observed in HD2 (12.63%) raises concerns regarding the potential for spoilage and mold growth, aligning with findings by Rajapaksh et al. (Rajapaksha et al., 2021), who emphasize that elevated humidity levels can lead to post-harvest losses. Conversely, ARZ1 displayed the highest weight (41.86 g), suggesting superior grain quality, as noted by Norman and coworkers (Norman et al., 2020), who associates higher weights with better overall seed vigor and viability. Specific weight measurements indicated that ARZ2 had the highest value (83.30), which corresponds to denser grains that can enhance processing efficiency (Rajapaksha et al., 2021). This is particularly relevant in industries where grain density influences milling and product yield. Furthermore, grain composition highlighted that HD1 had the highest percentage of whole grains (91.72%), an important factor in determining market value, as whole grains are often preferred for their nutritional benefits (Khajoane, 2022).

The purity of flour is influenced by its average ash content, extraction rate, and the mineralization of the wet grains(Ahmadi et al., 2024). As noted by Ahmadi and coworkers, ash content is critical in defining commercial flour types. The ash content results show that all varieties analyzed meet the Algerian standard, ensuring acceptable quality for flour production. The lower extraction rate of 71.5% suggests that there may be opportunities to optimize the milling process to increase flour yield. Thus, further technological tests are recommended to enhance milling efficiency and maximize flour output.

The low water content observed in our varieties can be attributed to the milling process employed, as described by some researchers (Cappelli et al., 2020; Mohidem et al., 2022). During milling, the flours are processed while being packaged, which creates a significant water gradient between the husks and the almond, facilitating better separation. This method effectively reduces the water content in the milling products.

Gluten content is crucial for the quality and performance of baked products. Higher wet gluten levels enhance dough elasticity and moisture retention, vital for achieving desirable textures in bread and pasta (Ronda et al., 2023). Strong gluten networks improve gas retention during fermentation, leading to better volume and crumb structure. Conversely, lower dry gluten can compromise dough integrity, resulting in denser products. Selecting the appropriate flour variety based on gluten characteristics is essential for optimal baking performance ((Dizlek and Awika, 2023). Additionally, milling techniques and environmental factors can influence gluten properties, highlighting the need for ongoing research to optimize flour quality.

Conclusion

The study highlights the suitability of various wheat varieties for crop production based on their soil conditions and physiological responses. The neutral pH and non-saline properties of the soil ensure a favorable environment for plant growth, with sandy loam texture promoting good drainage and aeration. Among the varieties tested, ARZ1 and HD1 demonstrated superior seed vigor and resilience to aging stress, maintaining high germination rates and root growth compared to ARZ2 and HD2, which were more susceptible to stress. The positive impact of treated wastewater on ARZ1's protein content further emphasizes its potential for enhanced crop quality. Overall, the findings underscore the importance of selecting appropriate varieties and irrigation methods to optimize agricultural practices and ensure sustainable crop production. Future research should focus on nutrient profiling and further assessment of these varieties in varying environmental conditions.

References

Achag, B., H. Mouhanni and A. Bendou. 2021. Design and performance analysis of a renewable pumping system for treated wastewater to reuse in the Moroccan desert. *Journal of Water and Climate Change,* 12, (8) 3958-3975.

Adetunji, A. E., T. L. Adetunji, B. Varghese, Sershen and N. W. Pammenter. 2021. Oxidative stress, ageing and methods of seed invigoration: an overview and perspectives. *Agronomy,* 11, (12) 2369.

Ahmadi, H., H. Mirseyed Hosseini, F. Moshiri, H. A. Alikhani and H. Etesami. 2024. Impact of varied tillage practices and phosphorus fertilization regimes on wheat yield and grain quality parameters in a five-year corn-wheat rotation system. *Scientific Reports,* 14, (1) 14717.

Ahmed, Z., I. Abduljabbar, S. Mousa, S. Abed and S. Owaid. 2020. The effect of changing the milling extraction rate on the flour properties. *Technology Reports of Kansai University TRKU,* 62, (03) 1121-1129.

Angelova, L., N. Genova, S. Stoyanova, O. Surleva, I.-H. Nekov, D. Ilieva and A. Surleva. 2021. Comparative study of soil test methods for determination of plant available potassium in Bulgarian arable soils. *Аналитика и контроль,* 25, (3) 182-192.

Arnon, D. I. 1949. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. *Plant physiology,* 24, (1) 1.

Awulachew, M. T. 2020. Understanding basics of wheat grain and flour quality. *Journal of Health and Environmental Research,* 6, (1) 10-26.

Baize, D. and B. Jabiol. 2011. Guide pour la description des sols.

Bradford, M. M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Analytical biochemistry,* 72, (1-2) 248-254.

Bouziani, M. 2000. Water from shortage to disease, Edition Ibn Khaldoun, (Oran Algeria). p247.

Cappelli, A., N. Oliva and E. Cini. 2020. Stone milling versus roller milling: A systematic review of the effects on wheat flour quality, dough rheology, and bread characteristics. *Trends in Food Science & Technology,* 97, 147-155.

Das, R. and S. Biswas. 2022. Influence of abiotic stresses on seed production and quality. In *Seed Biology Updates*: IntechOpen. Number of.

Dizlek, H. and J. M. Awika. 2023. Determination of basic criteria that influence the functionality of gluten protein fractions and gluten complex on roll bread characteristics. *Food Chemistry,* 404, 134648.

Dradrach, A., M. Iqbal, K. Lewińska, N. Jędroszka, M. a. K. Rana and H. S. Tanzeem-Ul-Haq. 2022. Effects of soil application of chitosan and foliar melatonin on growth, photosynthesis, and heavy metals accumulation in wheat growing on wastewater polluted soil. *Sustainability,* 14, (14) 8293.

Du, M., W. Zhang, J. Gao, M. Liu, Y. Zhou, D. He, Y. Zhao and S. Liu. 2021. Improvement of root characteristics due to nitrogen, phosphorus, and potassium interactions increases rice (*Oryza sativa* L.) yield and nitrogen use efficiency. *Agronomy,* 12, (1) 23.

Eddabra, R., W. Moussaoui, G. Prévost, F. Delalande, A. Van Dorsselaer, O. Meunier, J.-M. Scheftel and R. Mimouni. 2011. Occurrence of *Vibrio cholerae* non-O1 in three wastewater treatment plants in Agadir (Morocco). *World Journal of Microbiology and Biotechnology,* 27, 1099-1108.

Fellahi, Z., 2017.Genetic analysis of a line x tester cross, response to selection and stress tolerance of soft wheat (*Triticum aestivum* L.) under semi-arid condition, PhD thesis in science, Univ. Ferhat Abbas Settif 1, 227p.

Fenollosa, E., L. Jené and S. Munné-Bosch. 2020. A rapid and sensitive method to assess seed longevity through accelerated aging in an invasive plant species. *Plant Methods,* 16, 1-11.

Hiscox, J. and G. Israelstam. 1979. A method for the extraction of chlorophyll from leaf tissue without maceration. *Canadian journal of botany,* 57, (12) 1332-1334.

Izzo, C., P. Vitillo, P. Di Pietro, V. Visco, A. Strianese, N. Virtuoso, M. Ciccarelli, G. Galasso, A. Carrizzo and C. Vecchione. 2021. The role of oxidative stress in cardiovascular aging and cardiovascular diseases. *Life,* 11, (1) 60.

Jaramillo, M. F. and I. Restrepo. 2017. Wastewater reuse in agriculture: A review about its limitations and benefits. *Sustainability,* 9, (10) 1734.

Joshi, N. 2021. Future crop suitability assessment and the integration of Orphan crops into Kenya's food systems.

Khajoane, T. J. 2022. Genotype and environmental effects on maize grain yield, nutritional value and milling quality.

Khalilzadeh, R., A. Pirzad, E. Sepehr, S. Khan and S. Anwar. 2020. Long-term effect of heavy metal–polluted wastewater irrigation on physiological and ecological parameters of *Salicornia europaea* L. *Journal of Soil Science and Plant Nutrition,* 20, 1574-1587.

Kibar, H., F. Sönmez and S. Temel. 2021. Effect of storage conditions on nutritional quality and color characteristics of quinoa varieties. *Journal of Stored Products Research,* 91, 101761.

Kul, R., M. Ekinci, M. Turan, S. Ors and E. Yildirim. 2020. How abiotic stress conditions affects plant roots. In *Plant roots*: IntechOpen. Number of.

Laboratory, R. S. 1954. *Diagnosis and improvement of saline and alkali soils*. US Department of Agriculture

Li, W., Y. Niu, Y. Zheng and Z. Wang. 2022. Advances in the understanding of reactive oxygen species-dependent regulation on seed dormancy, germination, and deterioration in crops. *Frontiers in Plant Science,* 13, 826809.

Minhas, P. 2021. DIAGNOSTIC CRITERIA FOR SALT-AFFECTED SOILS. *Sustainable Agriculture,* 26.

Mohidem, N. A., N. Hashim, R. Shamsudin and H. Che Man. 2022. Rice for food security: Revisiting its production, diversity, rice milling process and nutrient content. *Agriculture,* 12, (6) 741.

Norman, P. E., A. Danquah, A. Asfaw, P. B. Tongoona, E. Y. Danquah and R. Asiedu. 2020. Seed viability, seedling growth and yield in white Guinea yam. *Agronomy,* 11, (1) 2.

Noura, M., B. Laid, B. Hammena, B. Ammar and B. Faiçal. 2021. Agronomic and Morpho-Physiological Characterization of Some Advanced Lines being Selected in Durum Wheat Cultivated in Semi-Arid Conditions. *Food Science and Engineering,* 65-78.

Rahal-Bouziane, H., S. Merdas and A. Abdelguerfi. 2015. Genetic diversity of traditional genotypes of barley (*Hordeum vulgare* L.) in Algeria by pheno-morphological and agronomic traits. *African journal of agricultural research,* 10, (31) 3041-3048.

Rajapaksha, L., D. Gunathilake, S. Pathirana and T. Fernando. 2021. Reducing post-harvest losses in fruits and vegetables for ensuring food security—Case of Sri Lanka. *MOJ Food Process Technols,* 9, (1) 7-16.

Ronda, F., S. Pérez-Quirce and M. Villanueva. 2023. Rheological properties of gluten-free bread doughs and their modification: improve bread quality. In *Advances in food rheology and its applications*:479-519: Elsevier. Number of 479-519 pp.

Sciarini, L. S., M. Bustos, M. B. Vignola, C. Paesani, C. Salinas and G. T. Perez. 2017. A study on fibre addition to gluten free bread: Its effects on bread quality and in vitro digestibility. *Journal of food science and technology,* 54, 244-252.

Shevela, D., J. F. Kern, G. Govindjee, J. Whitmarsh and J. Messinger. 2021. Photosystem II. *eLS,* 2, (7) 1-16.

Simkin, A. J., L. Kapoor, C. G. P. Doss, T. A. Hofmann, T. Lawson and S. Ramamoorthy. 2022. The role of photosynthesis related pigments in light harvesting, photoprotection and enhancement of photosynthetic yield in planta. *Photosynthesis Research,* 152, (1) 23-42.

Zaouri, N., H. Cheng, F. Khairunnisa, A. Alahmed, I. Blilou and P.-Y. Hong. 2021. A type dependent effect of treated wastewater matrix on seed germination and food production. *Science of The Total Environment,* 769, 144573.

Zheng, F., J. Wang, R. Xiao, W. Chai, D. Xing and H. Lu. 2021. Dissolved organic nitrogen in wastewater treatment processes: Transformation, biosynthesis and ecological impacts. *Environmental Pollution,* 273, 116436.